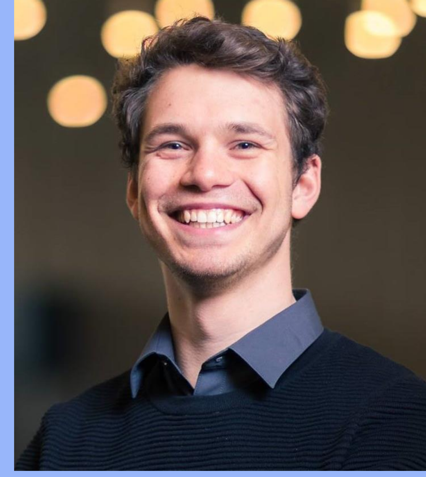
Bioleaching of metals from secondary materials using glycolipid biosurfactants



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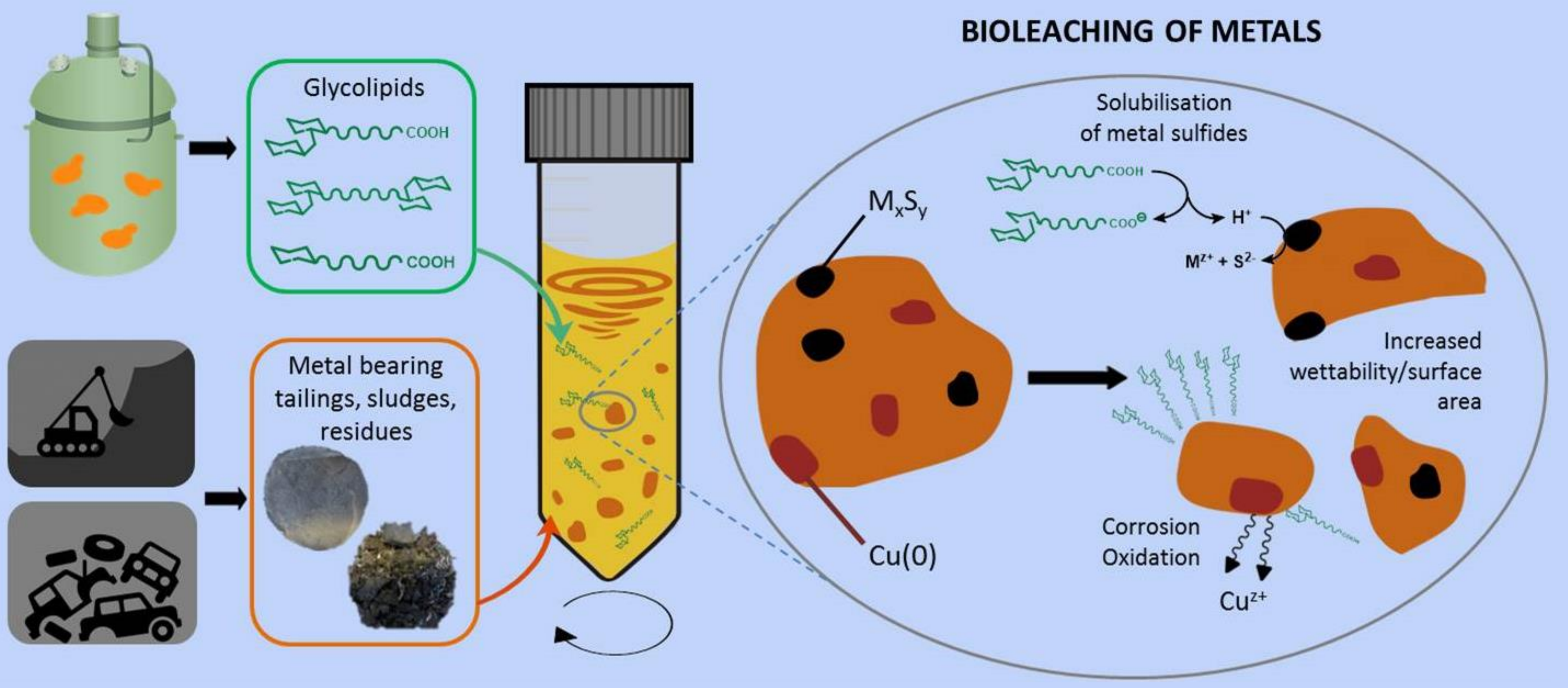
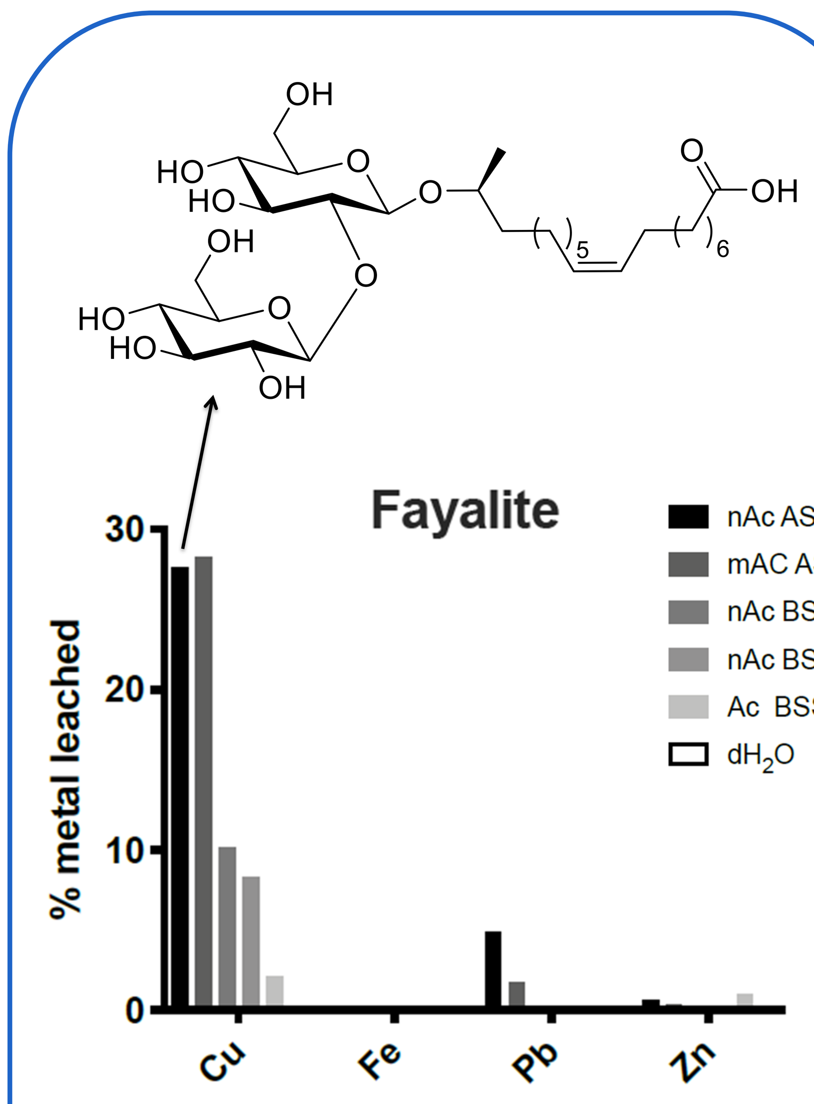
Introduction

With the global demand for economically important metals increasing, compounded by the depletion of readily accessible ores, secondary resources and low-grade ores are being targeted to meet growing demands. Novel technologies developed within biobased industries, such as microbial biosurfactants, could be implemented to improve the sustainability of traditional hydrometallurgy techniques. This study investigates newly developed microbial biosurfactants (acidic- and bolaform glycolipids) for the leaching of metals (particularly Cu) from a suite of mine tailings, metallurgical sludges and automotive shredder residues. This study highlights that acidic sophorolipid microbial biosurfactants have the potential to leach Cu from low-grade secondary materials. It also provides important fundamental insights into biosurfactant-metal and mineral interactions that are currently unexplored. Together, the convergence of leaching and mining industries with bio-industries can improve material recovery and will positively impact the bio- and circular economies and the environment.

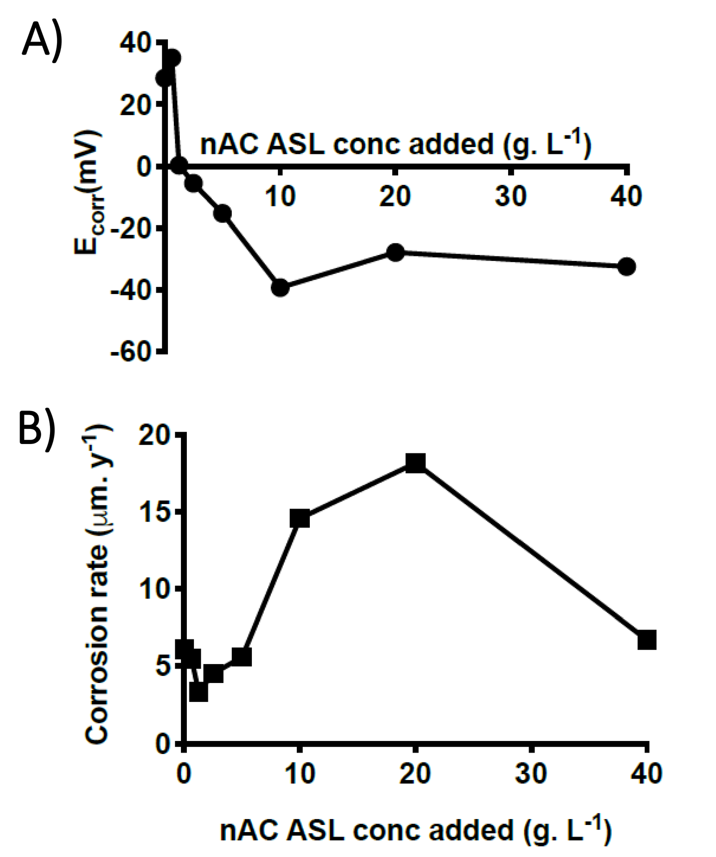


Results

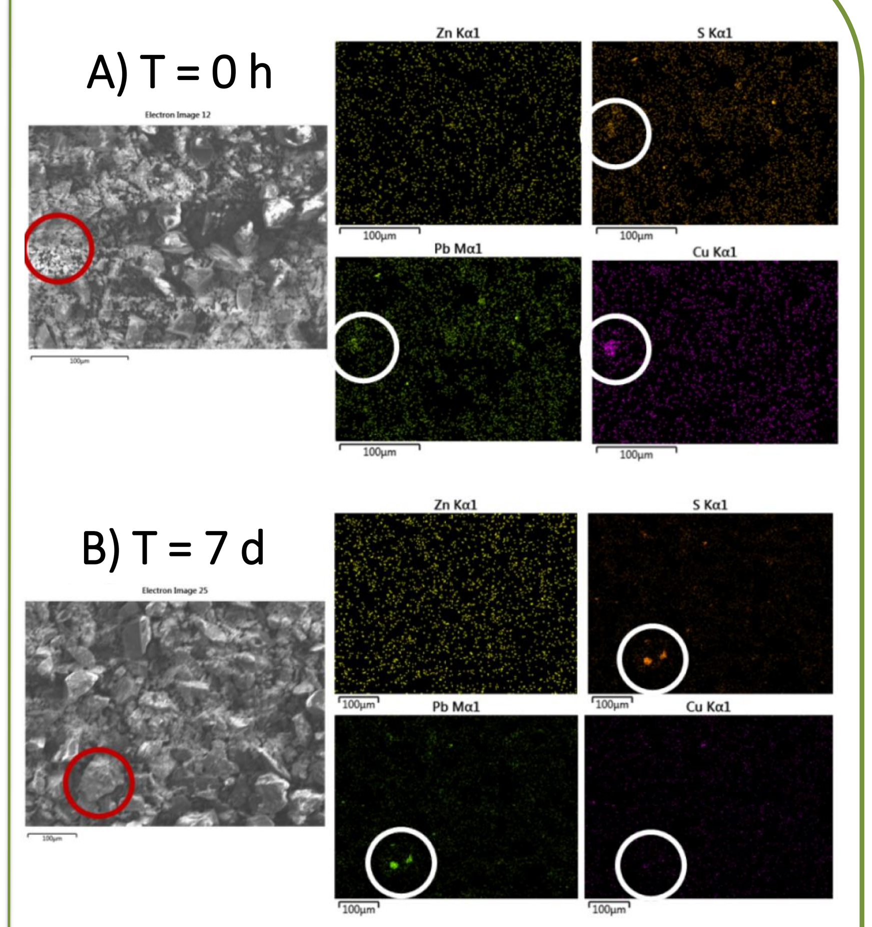


nAc = non-acetylated, Ac = acetylated, ASL = acidic sophorolipid, BS(L/S) = bolaform sophoro(lipid/side)

Optimal Cu leaching was observed from a fayalite slag (27%). Generally, acidic sophorolipids showed to be very performant.

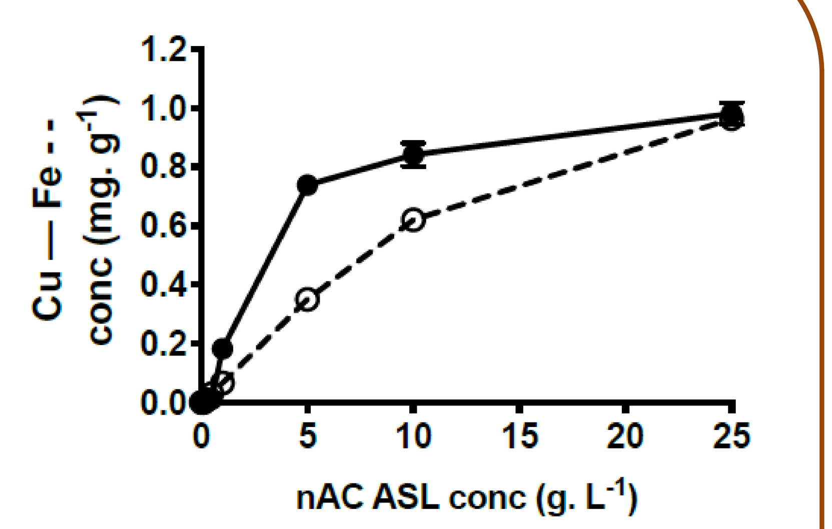


Corrosion potential (A) and corrosion rate (B) determined from Tafel plots. The increasing concentration of non-acetylated acidic sophorolipid shows the susceptibility of metallic Cu(0) towards corrosion.



SEM imaging and corresponding EDX mapping on (A) starting material, (B) long leaching (7d) of the fayalite with the non-acetylated acidic (10 g.L-1) sophorolipid. Cu-Pb sulfides have been encircled.

Further investigation of the leached fayalite material showed that leaching with non-acetylated acidic sophorolipids was occurring from small metallic Cu droplets in this material via a corrosion-based mechanism, and/or from Cu-Pb sulfides, selective against dominant Fe-silicate matrices.



Leached Cu and Fe in function of BS concentration. Leaching experiments were set up above and below the critical micelle concentration (CMC: 0.216 g.L-1) of the non-acetylated acidic Sophorolipid (nAC ASL), from 0.1 to 25 g.L-1.

A decrease in final pH from 6.5 (0 g.L-1) to 4.3 (25 g.L-1) was not enough to limit CuS solubility (modelling). It could be deduced that leaching inhibition through passive Cu layers (CuO, Cu(OH)2, sulphides) and strong biosurfactant-fayalite bonds was also unlikely.

Concentration experiment results highlight that copper leaching in the fayalite was restricted by limited extractable Cu0 and CuS phases. Rather, Cu may be associated with fayalite as cuprospinel phases.

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